

## FUEL AND OIL HEAT MANAGEMENT SYSTEM FOR A GAS TURBINE ENGINE

### FIELD OF THE INVENTION

The present invention relates to a system for transferring heat energy between the fuel and lubricating oil of a gas turbine engine or the like.

### BACKGROUND

The cooling requirements of gas turbine engines are well known to the designers of today's high performance aircraft powerplants. Certain internal structures, such as bearings, are both cooled and lubricated by a circulating flow of oil which is distributed and collected throughout the main engine structure, returning to a central collection point after having absorbed significant heat energy. Another source of heat is the accessory drive system coupled to the main engine by a mechanical drive and clutch system. Such accessory drives, for example a constant speed drive for the aircraft service electrical generator, are also provided with an independent circulating flow of oil for lubricating and cooling purposes.

One method of cooling the circulating oil loops described above is through the use of air-oil coolers and a flow of relatively cool compressor bleed air. Such coolers, while effective, diminish the overall engine operating efficiency since the extraction of bleed air increases overall engine power demand for a given level of useful thrust. This power penalty results in an increase in engine thrust specific fuel consumption.

Another method, often used in conjunction with air cooling, is to reject heat from the circulating oil loops into the flow of fuel entering the engine combustion chamber. This method uses the fuel flow as a convenient, recuperative heat sink and incurs few of the penalties of air cooling, but is limited in effectiveness by the maximum temperature tolerable by the fuel.

In order to appreciate the design problems associated with the management of heat generated in these systems, a brief discussion of the function and heat output of each is required. Cooling oil circulating through the main engine lubrication system receives heat energy at a rate related to the product of engine rotor speed and power output. The cooling needs of the main engine lubrication loop are thus at a minimum during periods of low power operation, such as idling, and at a maximum during high or full power operation, such as take-off. Normal engine operation under cruise conditions would fall between the two ranges but closer to the higher power conditions.

The lubricating and cooling oil of the accessory drive, and particularly for an accessory drive provided for the airframe electrical generator, does not receive heat energy proportional to the engine speed and power level but rather as a function of the electrical demand of the airframe. The accessory drive's maximum heat rejection demand may therefore occur at nearly any time in the operation of the aircraft, depending on the number of ovens, coffee makers, reading lamps, electrical heaters, or other power consuming devices switched on in the airframe at any particular time. The accessory heat rejection demand also varies less overall than that of the engine lubrication system, with the minimum heat rate being about one-half of the maximum heat rejection rate.

Against the heat production of the main engine lubrication system and the accessory drive, the needs of the fuel stream must also be considered and balanced. It is typical in gas turbine engine installations to deliver the fuel to the engine combustor by a positive displacement pump connected mechanically to the rotating engine shaft. It will be appreciated by those skilled in the art that a positive displacement pump, such as a gear pump or the like, delivers a volumetric flow rate directly proportional to the speed of the pump. As the flow rate from a pump turning proportional to engine shaft speed could never be made to match the fuel flow requirements of an aircraft gas turbine engine operating under a variety of power level demands and environmental conditions, it is common in the industry to size the positive displacement main fuel pump with an excess flow capacity under all engine operating conditions. The fuel system thus must include a fuel control valve and a bypass or return fuel line for routing the excess main fuel pump output back to the low pressure side of the pump.

The use of a pump bypass, common in many fluid flow applications, normally does not impact the operation of the fuel supply subsystem in an aircraft application. Under certain operating conditions, however, such as engine idling either in flight or on the ground, it will be nonetheless apparent that the amount of fresh fuel entering the fuel system is small while the relative volume of fuel being bypassed back to the pump inlet is quite large. The combination of pump inefficiency and recirculation of the excess main fuel pump output through the bypass line can heat the circulating fuel to an undesirably high temperature making it necessary to provide at least temporary cooling to the fuel supply system for idle operation.

Various methods have been proposed in the art for accommodating the widely varying needs of the fuel supply system, main engine lubrication system, and the accessory drive unit. U.S. Pat. No. 4,151,710 "Lubrication Cooling System for Aircraft Engine Accessory" issued May 1, 1979 to Griffin et al, shows disposing the accessory drive fuel-oil heat exchanger downstream with respect to the engine fuel-oil heat exchanger in the fuel supply line. The circulating accessory oil is routed through or around the accessory fuel-oil heat exchanger and an air-oil cooler in order to manage the accessory drive heat rejection. The reference also discloses removing heat energy from the fuel stream during periods of excessive fuel temperature, such as during ground idle. The total fuel flow passes through both the engine lubrication system fuel-oil cooler and the accessory drive fuel-oil cooler.

Such prior art systems, while effective, lack the flexibility for efficiently accommodating the wide variations in heat generation occurring in the various systems described. In the subject reference, for example, by sizing the accessory fuel-oil cooler to accommodate the maximum mass flow of fuel in the fuel supply line, it is necessary to increase the size of the accessory fuel-oil heat exchanger so as to accommodate the higher fuel throughput. Additionally, by placing the accessory drive heat exchanger downstream of the engine lubrication system fuel-oil heat exchanger, the referenced arrangement limits the fuel cooling available to the accessory drive unit, requiring additional air-oil cooling capacity to achieve current stringent accessory drive oil temperature requirements.